THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

082 **ELECTRICAL ENGINEERING SCIENCE**

(For Both School and Private Candidates)

Time : 3 Hours **ANSWERS** **Year : 2007**

Instructions

1. This paper consists of sections A, B and C.
2. Answer all questions in section A and B and **three (3)** questions from section C.
3. Non-programmable calculators may be used.
4. Communication devices and any unauthorised materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

(i) The following material is suitable for making filament of incandescent lamps.

A. Brass

B. Tungsten

C. Argon

D. Copper

E. Mercury

Correct answer: B. Tungsten

Reason: Tungsten has a very high melting point (about 3400 °C) and high tensile strength, making it ideal for lamp filaments since it can withstand high temperatures without melting.

(ii) The unit used to measure luminous intensity is

A. lumen/m^2

B. candela

C. lux

D. lumen

E. candela/m^2

Correct answer: B. candela

Reason: Luminous intensity is defined as the luminous flux emitted in a given direction per unit solid angle, and its SI unit is candela (cd).

(iii) Normally a transformer is laminated in order to

A. reduce power factor

B. reduce armature reaction

C. increase power loss

D. reduce eddy current

E. increase eddy current

Correct answer: D. reduce eddy current

Reason: Laminating the core increases resistance to circulating eddy currents, which reduces eddy current losses and heating in the transformer.

(iv) The instrument that is used to measure both A.C and D.C is known as

A. moving iron instrument

B. moving coil instrument

C. clamp meter

D. tacho metre

E. current meter

Correct answer: A. moving iron instrument

Reason: Moving iron instruments work based on the magnetic effect of current and can measure both alternating and direct currents. Moving coil instruments only measure d.c. unless modified.

(v) The type of light source are

A. Discharge and incandescent lamps

B. Generators and incandescent lamps

C. Batteries and incandescent lamps

D. Magnetism and incandescent lamps

E. Batteries and magnetism

Correct answer: A. Discharge and incandescent lamps

Reason: Light sources can be classified as incandescent lamps (filament-based) and discharge lamps (fluorescent, mercury vapor, sodium vapor, etc.).

(vi) The extra low voltage for dc supply is

A. 30 V

B. 50 V

C. 240 V

D. 10 V

E. 25 V

Correct answer: B. 50 V

Reason: Extra low voltage is defined as not exceeding 50 V for d.c. (and 24 V for a.c.) according to international electrical standards.

(vii) Usually a rectifier is made by using the following components:

A. Transistors

B. Capacitors

C. Diodes

D. Resistors

E. Thyristor

Correct answer: C. Diodes

Reason: A rectifier converts a.c. to d.c. and the main component used is a diode, which allows current to pass in one direction only.

(viii) Torque is the turning moment produced by a force about an axis or centre of rotation which is measured by the following unit:

A. Nm

B. Wb

C. W

D. m/s

E. Wb/m

Correct answer: A. Nm

Reason: Torque = Force × perpendicular distance. Its SI unit is Newton meter (Nm).

(ix) The unit of the reluctance, s, of a magnetic circuit is

A. V/d

B. N/t

C. m.m.f / flux

D. V/A

E. m.m.f / t

Correct answer: C. m.m.f / flux

Reason: Reluctance is defined as the opposition to magnetic flux in a magnetic circuit, given by Reluctance = Magnetomotive force (m.m.f) / Flux.

(x) Which of the following instruments is used for testing high voltage?

A. Galvanometer

B. Potential meter

C. Multimeter

D. Voltage transformer

E. Voltmeter

Correct answer: D. Voltage transformer

Reason: Voltage transformers (potential transformers) are designed to measure and test high voltages safely by stepping them down to measurable levels, while ordinary voltmeters cannot directly handle very high voltages.

2. Define the term “armature reaction” of a DC machine.

Armature reaction is the effect of the magnetic field produced by the armature current on the distribution of flux under the main poles of a DC machine. It distorts and weakens the main flux, causing sparking at the brushes and reducing efficiency.

3. Mention the main parts of an AC machine.

The main parts of an AC machine are the stator, rotor, frame, shaft, and bearings. The stator carries the armature winding or field winding, while the rotor carries the corresponding counterpart, enabling electromagnetic induction.

4. Calculate the illumination of a working plane at a point G, 4 m vertically below a lamp emitting 800 cd. The surface is at right angles to the light source.

Illumination, $E = I / d^2$

$E = 800 / (4^2) = 800 / 16 = 50$ lux

5. Why are transformers rated in KVA?

Transformers are rated in kVA instead of kW because their losses depend on voltage (iron losses) and current (copper losses), not on the power factor. Since power factor varies with load, kVA rating is used as it is independent of load power factor.

6. Write down the instruments used to measure the following quantities:
   (a) Illumination – Lux meter
   (b) Resistance – Ohmmeter or Wheatstone bridge
   (c) Electric energy – Energy meter (kWh meter)

7. Explain the meaning of the word “polarization” then mention the instrument used to measure the specific gravity of a battery.

Polarization is the phenomenon in an electrolytic cell where hydrogen bubbles accumulate on the surface of the electrode, increasing internal resistance and reducing efficiency. The specific gravity of a battery is measured using a hydrometer.

8. The frequency of an oscillating quantity is 60 Hertz. What is the period of oscillation?

Period T = 1 / f = 1 / 60 = 0.0167 s

9. List down three (3) methods which can be used to improve low power factor.

Use of capacitors in parallel with the load to supply reactive power.
Using synchronous condensers which operate at leading power factor.
Using phase advancers in induction motors.

10. Write down six (6) methods that are used to generate electricity.

Hydropower generation using water turbines.
Thermal power generation using coal, oil, or gas.
Nuclear power generation using nuclear fission.
Solar power generation using photovoltaic cells.
Wind power generation using wind turbines.
Geothermal power generation using steam from underground sources.

11. Mention three (3) types of discharge lamps.

Fluorescent lamps.
Mercury vapor lamps.
Sodium vapor lamps.

SECTION C (60 marks)

Answer three (3) questions from this section

12. Find the efficiency of water heater which heats 140 litres of water from 10°C to 60°C in 3 hours. The water is heated by a 3 kilowatts element.

Mass of water = 140 litres = 140 kg (1 litre = 1 kg)
Specific heat capacity of water = 4200 J/kg°C
Temperature rise = 60 – 10 = 50°C

Heat required = $mc\Delta T = 140 \times 4200 \times 50 = 29{,}400{,}000$ J

Time = 3 h = 3 × 3600 = 10,800 s
Input energy = Power × time = 3000 × 10,800 = 32,400,000 J

Efficiency = (Output/Input) × 100 = (29,400,000 / 32,400,000) × 100 = 90.7 %

13. (a) By using a neat diagram explain how you can extend the range of a voltmeter.

The range of a voltmeter can be extended by connecting a suitable high resistance (multiplier) in series with the meter movement. This limits the current through the coil, allowing measurement of higher voltages.

(b) A moving coil instrument gives a full scale deflection (FSD) with a current of 30 mA and a voltage of 90 mV. Calculate the value of a resistor to be connected with the instrument so that it can be used to read 0 – 100 V.

Internal resistance of meter, Rm = V/I = 0.09 / 0.03 = 3 Ω
Total resistance required = V/I = 100 / 0.03 = 3333.3 Ω
Series resistance = Total – Rm = 3333.3 – 3 = 3330.3 Ω ≈ 3.33 kΩ

14. The resistance of a shunt winding of dc machine is measured before and after a run of several hours. The average values are 55 Ω and 63 Ω. Calculate the rise in temperature of the winding. Assume the room temperature of 15°C. Temperature coefficient of resistance of copper is 0.00428/°C.

$Rt = R0 [1 + \alpha (T – T0)]$

$63 = 55 [1 + 0.00428 (T – 15)]$

$63 / 55 = 1 + 0.00428 (T – 15)$

$1.145 = 1 + 0.00428 (T – 15)$

$0.145 = 0.00428 (T – 15)$

$T – 15 = 0.145 / 0.00428 = 33.9°C$

$T = 48.9°C$

Rise in temperature = 48.9 – 15 = 33.9°C

15. Two capacitors A and B of capacitance 2 μF and 4 μF respectively are connected in series to a dc supply. Charge stored by each capacitor = 0.16 mC. Determine the:
    (a) potential difference across each capacitor
    (b) energy stored by each capacitor
    (c) effective capacitance of series combination
    (d) total energy stored

Charge, $Q = 0.16 \text{ mC} = 0.16 \times 10^{-3} \text{ C}$

(a) $V = Q/C$

$VA = 0.16 \times 10^{-3} / 2 \times 10^{-6} = 80 \text{ V}$

$VB = 0.16 \times 10^{-3} / 4 \times 10^{-6} = 40 \text{ V}$

(b) Energy = $\frac{1}{2} CV^2$

$EA = \frac{1}{2} \times 2 \times 10^{-6} \times (80^2) = 6.4 \times 10^{-3} \text{ J}$

$EB = \frac{1}{2} \times 4 \times 10^{-6} \times (40^2) = 3.2 \times 10^{-3} \text{ J}$

(c) Effective capacitance = $(C1 \times C2) / (C1 + C2) = (2 \times 4) / (2 + 4) = 8/6 = 1.33 \text{ μF}$

(d) Total energy stored = $EA + EB = 6.4 \times 10^{-3} + 3.2 \times 10^{-3} = 9.6 \times 10^{-3} \text{ J}$

16. (a) What is a pure inductive circuit?

A pure inductive circuit is one in which only inductance is present without resistance or capacitance. In such a circuit, current lags the voltage by 90°.

(b) A circuit consists of inductor, capacitor and resistor of 10 Ω, 4 Ω and 8 Ω respectively. If the components are connected in series across 240 volts and 50 Hz, calculate the current of a circuit.

R = 8 Ω, XL = 10 Ω, XC = 4 Ω
Net reactance, X = XL – XC = 10 – 4 = 6 Ω
Impedance, $Z = \sqrt{(R^2 + X^2)} = \sqrt{(8^2 + 6^2)} = \sqrt{(64 + 36)} = \sqrt{100} = 10\ \Omega$
Current, I = V / Z = 240 / 10 = 24 A

(c) Draw the vectorial (phasor) relationship between voltage and current of the above circuit.

In the phasor diagram, the voltage across the resistor is in phase with current, the voltage across the inductor leads current by 90°, and the voltage across the capacitor lags current by 90°. The resultant supply voltage is the vector sum of VR, VL, and VC.